CLAIMS

1. A charged particle beam apparatus comprising:

a work piece vacuum chamber for containing a work piece and having a background chamber pressure;

a charged particle beam source;

a charged particle beam optical column for directing a particle beam along an optical axis toward the work piece;

a charged particle detector comprising a volume including a detector gas ionizable by the charged particles, electrodes to produce an electric field to cause the ionization to take place, and a detector plate to detect signals induced in the ionized gas, the charged particle detector including a passage for delivery of the detector gas to maintain the pressure of the detector gas around the detector sufficient to operate the detector, while maintaining the pressure in the work piece vacuum chamber at a significantly lower pressure.

2. The apparatus of claim 1 in which the charged particle beam column comprises a scanning electron microscope column.

3. The apparatus of claim 1 in which the charged particle detector comprises two plates, each plate having an aperture co-axial with the optical axis.

4. The apparatus of claim 3 in which the gas passes in between the two plates.

5. The apparatus of claim 1 in which the passage for delivery of gas comprises a nozzle directing gas toward a region between the detector plate and a work piece position.

6. A charged particle beam apparatus comprising:

a work piece vacuum chamber for containing a work piece and having a background chamber pressure

a charged particle beam source;

a charged particle beam optical column for directing a particle beam along an optical axis toward the work piece;

an ion generator in which secondary particles generated by the impact of charged particle beam on a work piece or particles from the primary beam backscattered by the work piece ionize an ion producing gas, the ion generator positioned such that at least some of the ions travel to work piece to neutralize charge on the work piece, the ion generator including a chamber containing a gas, the chamber connected to the work piece vacuum chamber though an aperture that allows secondary or backscattered particles from the work piece to enter the chamber and allows ions to exit the chamber to neutralize charge on the work piece.

7. The charged particle beam apparatus of claim 6 in which the charged particle beam optical column includes an objective lens and an optical axis and in which ion generator is positioned such that a line drawn from the center of the aperture to the intersection of the optical axis with the work piece is not parallel to the optical axis.

8. The charged particle beam apparatus of claim 6 in which the charged particle beam optical column comprises a scanning electron microscope column.

9. A charged particle beam apparatus comprising:

a work piece vacuum chamber for containing a work piece and having a background chamber pressure

a charged particle beam source;

a charged particle beam optical column for directing a particle beam toward the work piece;

an ion generator in which secondary particles generated by the impact of charged particle beam on a work piece or particles from the primary beam backscattered by the work piece ionize an ion producing gas, the ion generator positioned such that at least some of the

ions travel to work piece to neutralize charge on the work piece, the ion generator configured such that the ion producing gas is maintained at a sufficiently high pressure at the ion generator to produce sufficient ions from the secondary or backscattered particles to neutralize charge accumulation on the work piece, while the background chamber pressure remains at a significantly lower pressure.

10. The charged particle beam apparatus of claim 9 in which the ion producing gas is maintained at a pressure greater than about 0.1 Torr and in which the background chamber pressure is maintained at a pressure of less than about 0.01 Torr.

11. The charged particle beam apparatus of claim 9 in which the ion producing gas is maintained at a pressure greater than about 0.3 Torr and in which the background chamber pressure is maintained at a pressure of less than about 10-3 Torr.

12. The charged particle beam apparatus of claim 9 in which the ion producing gas is maintained at a pressure greater than about 0.4 Torr and in which the background chamber pressure is maintained at a pressure of less than about 10-3 Torr.

13. The charged particle beam apparatus of claim 9 in which the ion generator comprises an environmental scanning electron microscope-type particle detector.

14. The charged particle beam apparatus of claim 13 in which the environmental scanning electron microscope-type particle detector comprises a plate having an aperture co-axial with the charged particle beam.

15. The charged particle beam apparatus of claim 14 in which the charged particle beam column includes a magnetic immersion objective lens and in which the detector plate is positioned above a work piece position and below a pole of the magnetic immersion objective lens.

16. The charged particle beam apparatus of claim 13 in which the particle detector includes a passage for transporting the ion producing gas.

17. The charged particle beam apparatus of claim 9 in which the charged particle beam includes an objective lens and an optical axis and in which ion generator is positioned such that a line drawn from the center of the aperture to the intersection of the optical axis with the work piece is not parallel to the optical axis.

18. The charged particle beam apparatus of claim 9 in which the ion generator comprises a chamber containing a gas, the chamber communicating to the work piece vacuum chamber though an aperture that allows secondary particles from the work piece to enter the chamber and allows ions to exit the chamber to neutralize charge on the work piece.

19. The charged particle beam apparatus of claim 9 in which the ion producing gas increases the etch rate of charged particle beam or decomposes in the presence of the charged particle beam to deposit a material on the work piece.

20. The charged particle beam apparatus of claim 9, further comprising: a second charged particle beam source; and a second charged particle beam column for directing a second beam of charged particles toward a work piece positioned in the work piece vacuum chamber, a detector for detecting charged particles emitted from the work piece upon impact of particles in the second charged particle beam, the pressure in the work piece vacuum chamber being sufficiently low to operate the second charged particle beam column.

21. An ion generator for controlling charge on a sample that produces secondary electrons as it is being worked on in a sample chamber, comprising:

a body having rear and forward ends and a gas inlet opening to be controllably supplied with a gas, the forward end having an aperture opening to receive the secondary electrons and to emit positively charged ions;

a detector electrode mounted within said body; and

a channel electrode mounted within the body between the detector electrode and the aperture opening to channel the secondary electrons toward the detector electrode, the channel and detector electrodes defining an inner volume, wherein the body is configured to maintain the supplied gas at least within the inner volume at a working pressure sufficiently higher than that of the sample chamber to promote gas ionization cascades thereby generating positively charged ions to be emitted from the inlet opening and providing an amplified secondary electron signal to the detector electrode.

22. The ion generator of claim 21, wherein the channel electrode is formed as part of the body.

23. The ion generator of claim 21, wherein the channel electrode is conical in shape.

24. The ion generator of claim 21, wherein the channel and detector electrodes are electrically isolated from one another.

25. The ion generator of claim 21, wherein the channel electrode further comprises a plurality of discretely biased electrode components.

26. The ion generator of claim 21, further comprising a controllable magnetic field generation structure proximal to the aperture opening for guiding secondary electrons into the aperture opening.